Construction and design calculation of parts and elements of RIGID Flange Coupling.

Rigid flange couplings are used to transmit pure torques between two coaxial shafts ends. Accordingly; casting, machining, assembly and functional considerations are accounted for in the sketches including the different alternatives. The proportions implied by these considerations are also given. The main related standards for the elements are also given.

The following procedure is a typical engineering approach which leads to a reliable, compact and well sized rigid flange coupling. This approach adopts irrational and rational design approaches when needed.

To take into consideration the working conditions of the driven machine, a service factor should be applied to the load to be transmitted.

* SERVICE FACTOR: (K_S)

Daily working hrs / load classification	up to 4 h	8 h	16 h	24 h
Steady	0.8	1	1.1	1.3
moderate shocks	1.1	1.2	1.4	1.5
heavy shocks	1.4	1.5	1.6	1.7

The values given are suitable for a number of starts per hour ranging from 10 to 200 starts/h.

Design Approach of a Rigid Flange Coupling:

1- Calculate, if not known, the shaft end diameter based on transmitted torque, service factor of the driven machine and starting condition:

Starting conditions: Load factor (K_L)

* Direct on load 2
* Star-delta (Y-Δ) starting 1.732
* Soft starter:
  - Online hydraulic coupling 1.25
  - Manually controled clutch 1.5

Margin of safety: applied to torsional yield stress (τ_y) a factor of $K_m = 1.3$

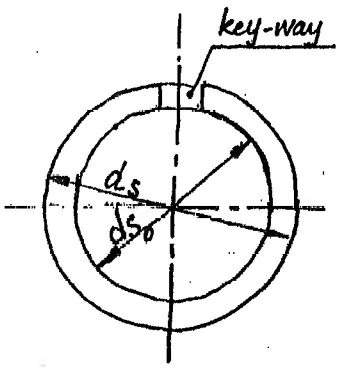
Service factor: see table for K_s

Select a suitable shaft material and hence,

$$\frac{\tau_y}{K_m} \geq \frac{16\, T_d}{\pi\, d_{s_o}^3}$$

$$T_d = \frac{71620\ HP}{n} * K_L * K_s$$

d_{s_o} = min. shaft diam.



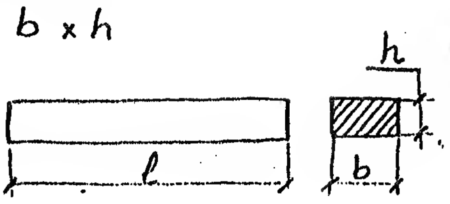
- From [DIN 748-1] select d_s & l
(From [DIN 6885-1] Select the key)

2- Based on proportions implied by basic manufacturing considerations, workout the dimensions (and then the details of construction) leading to the nominal bolt size and the pitch circle diameter.

3- Check the key dimensions :

key cross-section = $b \times h$

key length = l



Select key material St.50 OR 60

- Shear strength:

$$\frac{\tau_y}{k_m} = (2T_d/d_s)/(b*l)$$

to find $l \leq 1.5\ d_s$

- Crushing stress

$$\sigma_{cr_{allowable}} = \left(\frac{400\ B.H.N. - 10{,}000}{1.4}\right)\ N/mm^2$$

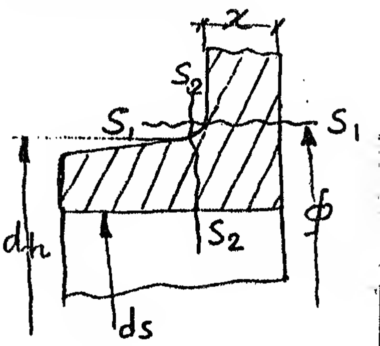
B.H.N. = Brinell hardness number of the annealed softer material (of the key, the shaft or the coupling hub)

(This formula is empirical)

4- Check flange at critical sections:

Section $S_1 - S_1$:

$$\tau_{working_1} = \frac{(2T_d/\phi)}{\pi\,\phi\,x} = \frac{2T_d}{\pi\,x\,\phi^2}$$



Section $S_2 - S_2$:

$$\tau_{working_2} = \frac{16\ T_d\ d_h}{\pi(d_h^4 - d_s^4)}$$

$\tau_{working_1}$ and $\tau_{working_2}$ should be $< \frac{\tau_u}{2*1.3}$

and hence select the suitable cast iron grade.

For	σ_u N/mm^2	τ_u N/mm^2	τ_{end} N/mm^2
GG-15	150	70	50
GG-25	250	120	90
GGG-40	400	190	140

5- Calculate the required number of bolts :-

Note:

The suitable bolt size is already figured out irrationaly from the construction laid down with reference to the basic manufacturing considerations. Taking into account the suitable bolt material, one can calculate the load which this bolt made of the selected material and of this size can adequately and safely sustain. There are two methods can be adopted to transmit the torque between the two flanges :

either by shear bolts / shear bushes

or by generating enough friction between flanges.

Depending upon the adopted method of transmiting the torque, the required number of bolts is rationaly calculated as follows :

5-1- Shear bolts / shear bushes :

Bolt (Shear bush) material, $\sigma_y = \checkmark$ & $\tau_y = 0.6\,\sigma_y$

Sheared area $= A_s$

margin of safety $= 1.3$

i.e. the shearing force the bolt can sustain $= P_s$

The pitch circle diameter $= D_p$

$\therefore$ The number of bolts $= \dfrac{2\,T_d / D_p}{P_s}$ where :

$T_d = T * K_L * K_s$ and

$P_s = A_s * \dfrac{\tau_y}{1.3}$

The number of bolts should be devisible by 2 (or 3)

5-2- Torque transmition by friction :

a) Bolt nominal diam. $= d$, pitch $= p$

core area $= A = \frac{\pi d_c^2}{4}$

$\therefore$ mean diam. $= d_m$

$\tan\alpha = p/\pi(d_m)$

$\mu_{thr.}$ = thread friction coefficient

$\mu' = \frac{\mu_{thr.}}{\cos\beta}$, $\beta = 30^\circ$ (metric thread)

Thread friction torque $= T_1 = P_a \frac{d_m}{2}\left[\frac{\tan\alpha + \mu'}{1-\mu'\tan\alpha}\right]$

where :

P_a is the axial load in the bolt (by tightening)

i.e. $\tau = \frac{16\,T_1}{\pi d_c^3} = \left[\frac{16}{\pi d_c^3}\left(\frac{d_m}{2}\right)\left(\frac{\tan\alpha + \mu'}{1-\mu'\tan\alpha}\right)\right] \cdot P_a$

also: $\sigma = \left[\frac{4}{\pi d_c^2}\right] \cdot P_a$

$\therefore \tau_{comb} = \frac{1}{2}\sqrt{\sigma^2 + 4\tau^2} = C \cdot P_a$

where C is a value already determined.

b) For a selected bolt material, $\sigma_y = \checkmark$, $\tau_y = 0.6\sigma_y$

$\therefore \frac{\tau_y}{\text{margin of Safety}} = \frac{\tau_y}{1.3} \geq C \cdot P_a$

$\therefore P_a = \checkmark\checkmark$ = The max. safe load per bolt

c) Friction coefficient between flanges $= \mu_f$

Friction ring mean diameter $= D_{fr}$

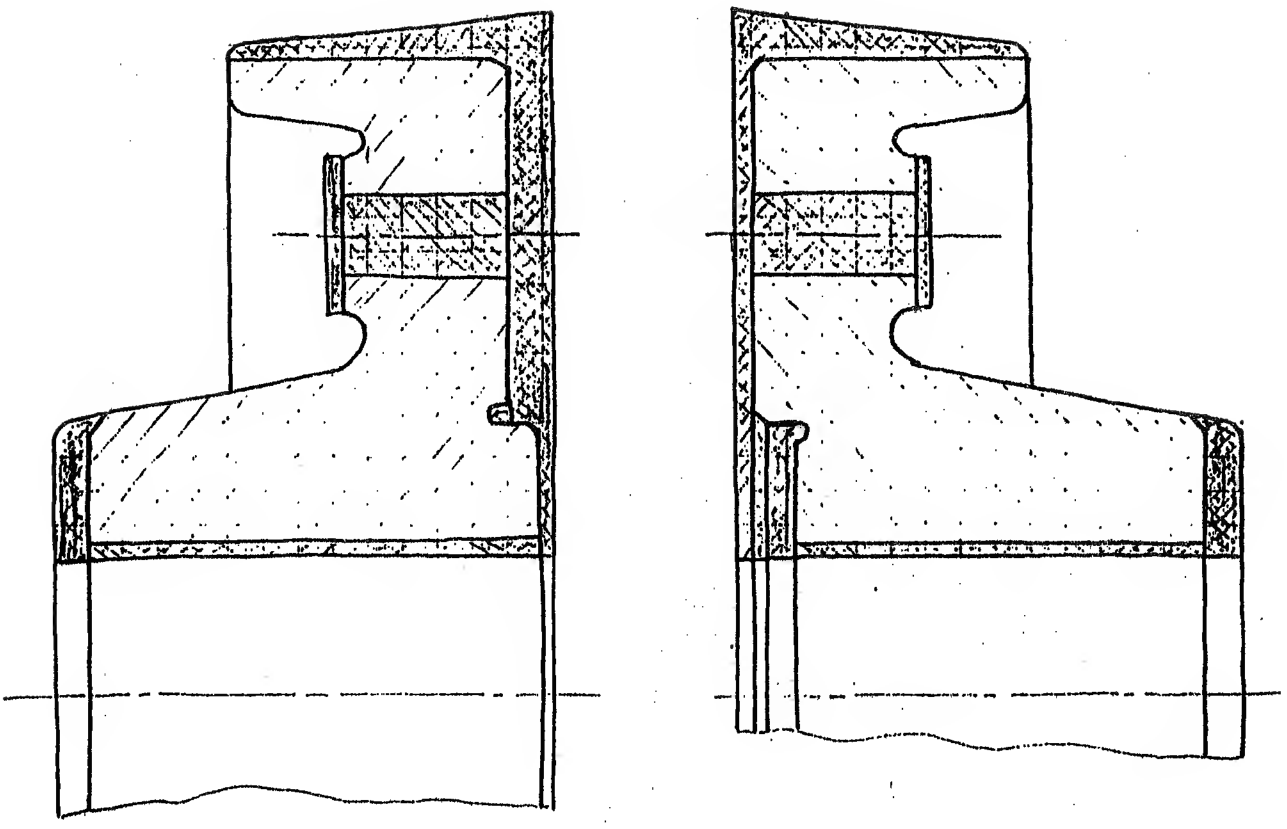
Total friction torque required $= 1.5 * T_d$

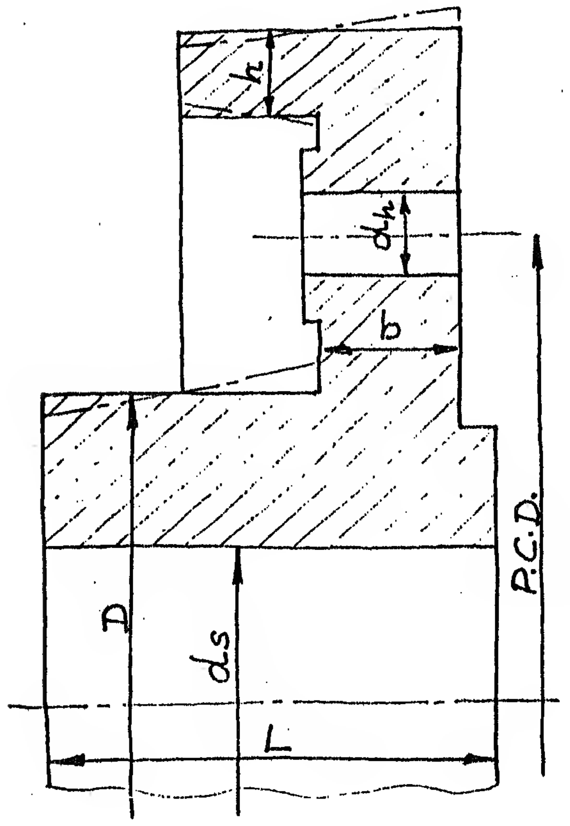
(the factor 1.5 is called a <u>security factor</u>.)

Total friction force $= \frac{1.5 * T_d}{(D_{fr}/2)} = F_{fr}$

d) No of bolts $= F_{fr}/(\mu_f \cdot P_a)$

Also : the number of bolts should be deivisible by 2 (or 3)





d_s = Shaft diam.

$D = 1.8 - 2\ d_s$

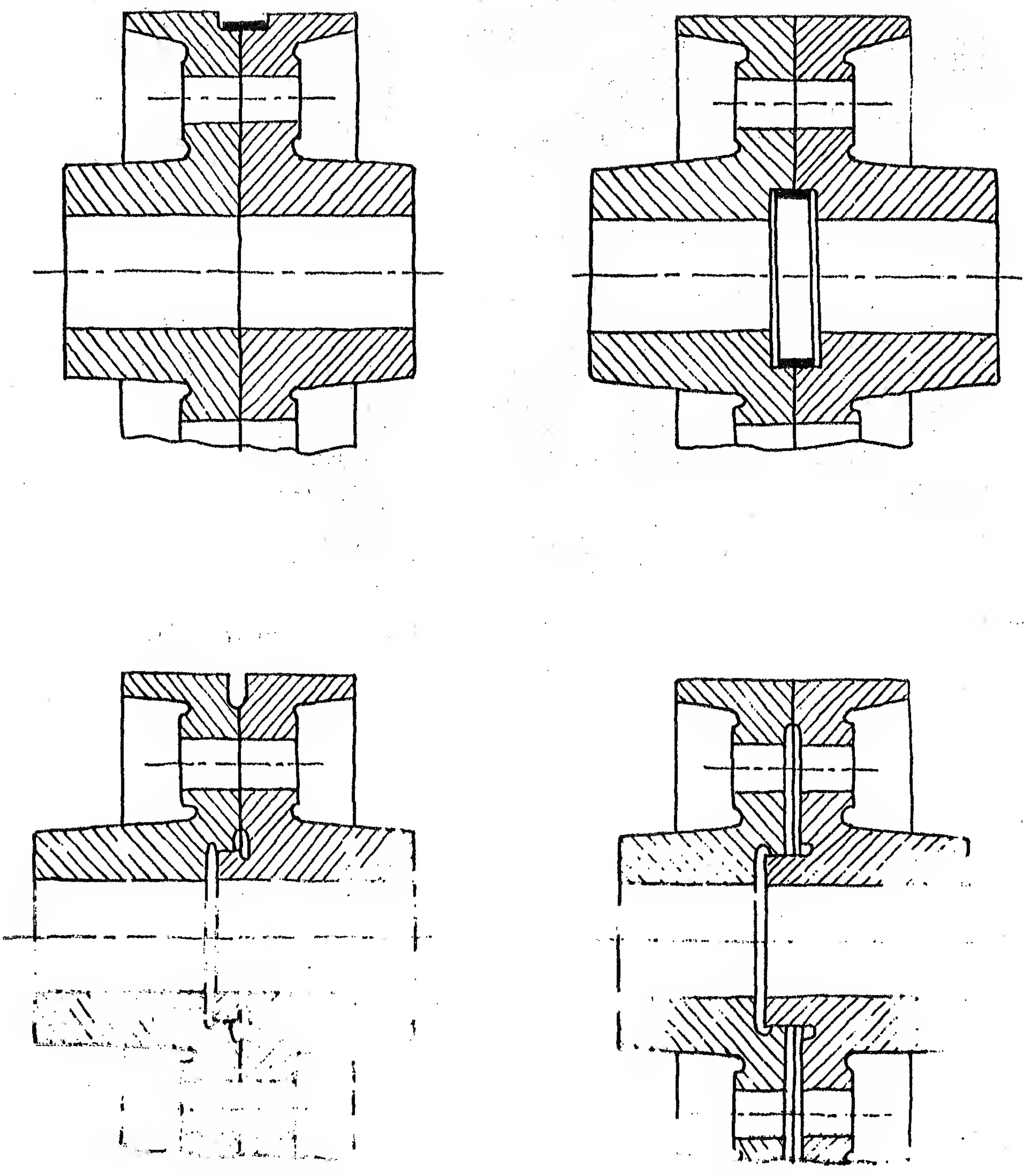
$L = 1.4 - 1.5\ d_s$

$b = 0.4 - 0.5\ d_s$

$d_h \cong 0.25 - 0.3\ d_s$

$h = 0.5 - 0.6\ b$

$P.C.D. \cong 3\ d_s$



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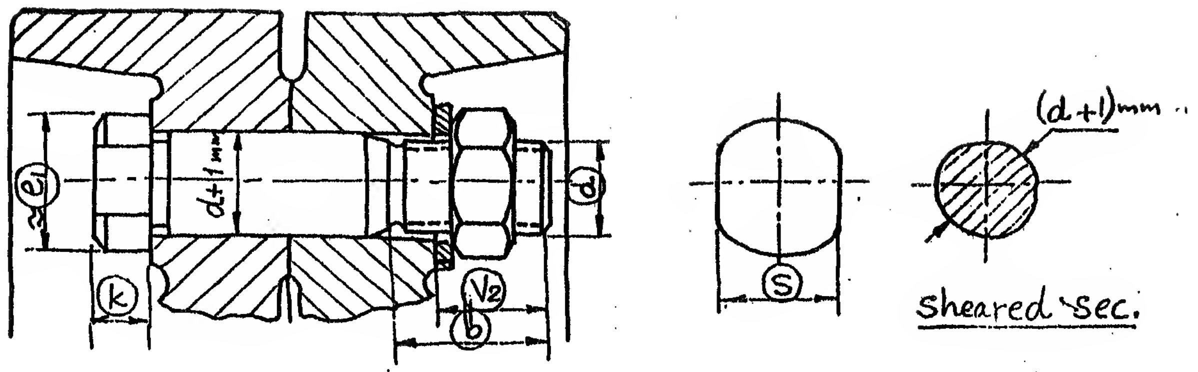
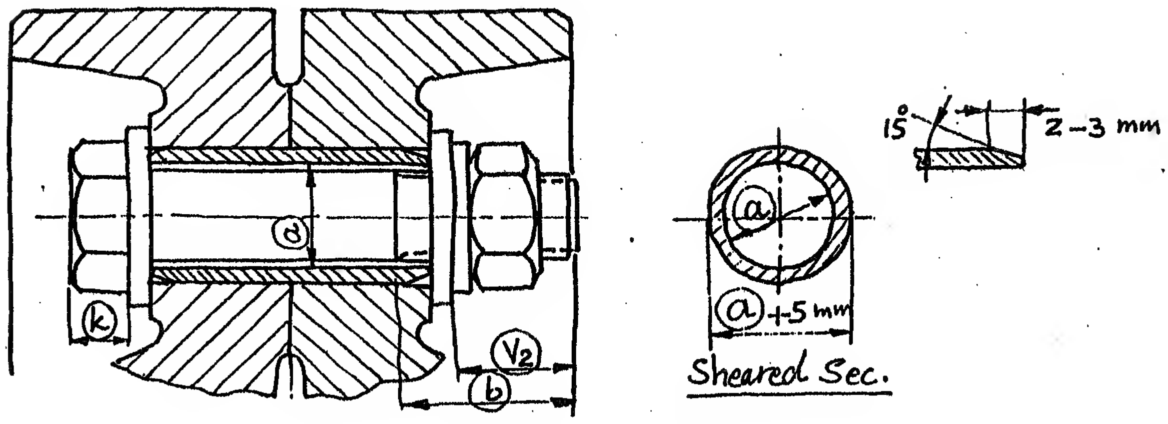
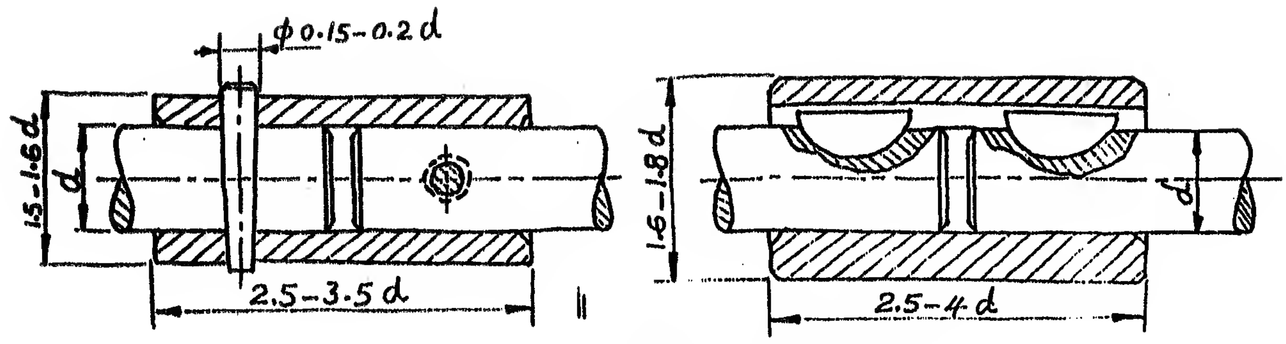
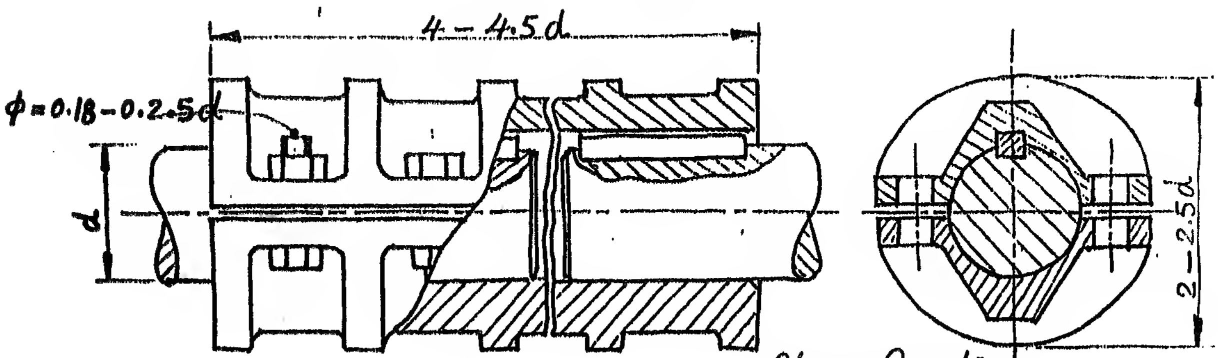




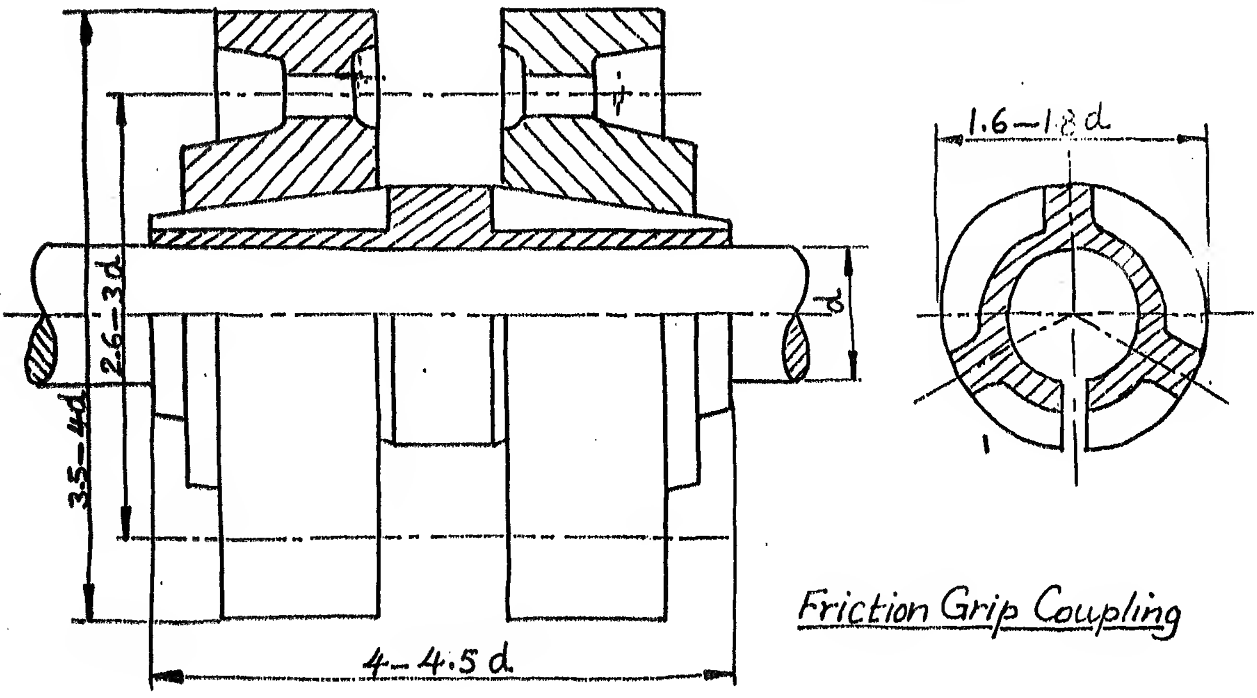
* Encircled dims. to be extracted from tables of standards.



Sleeve Couplings

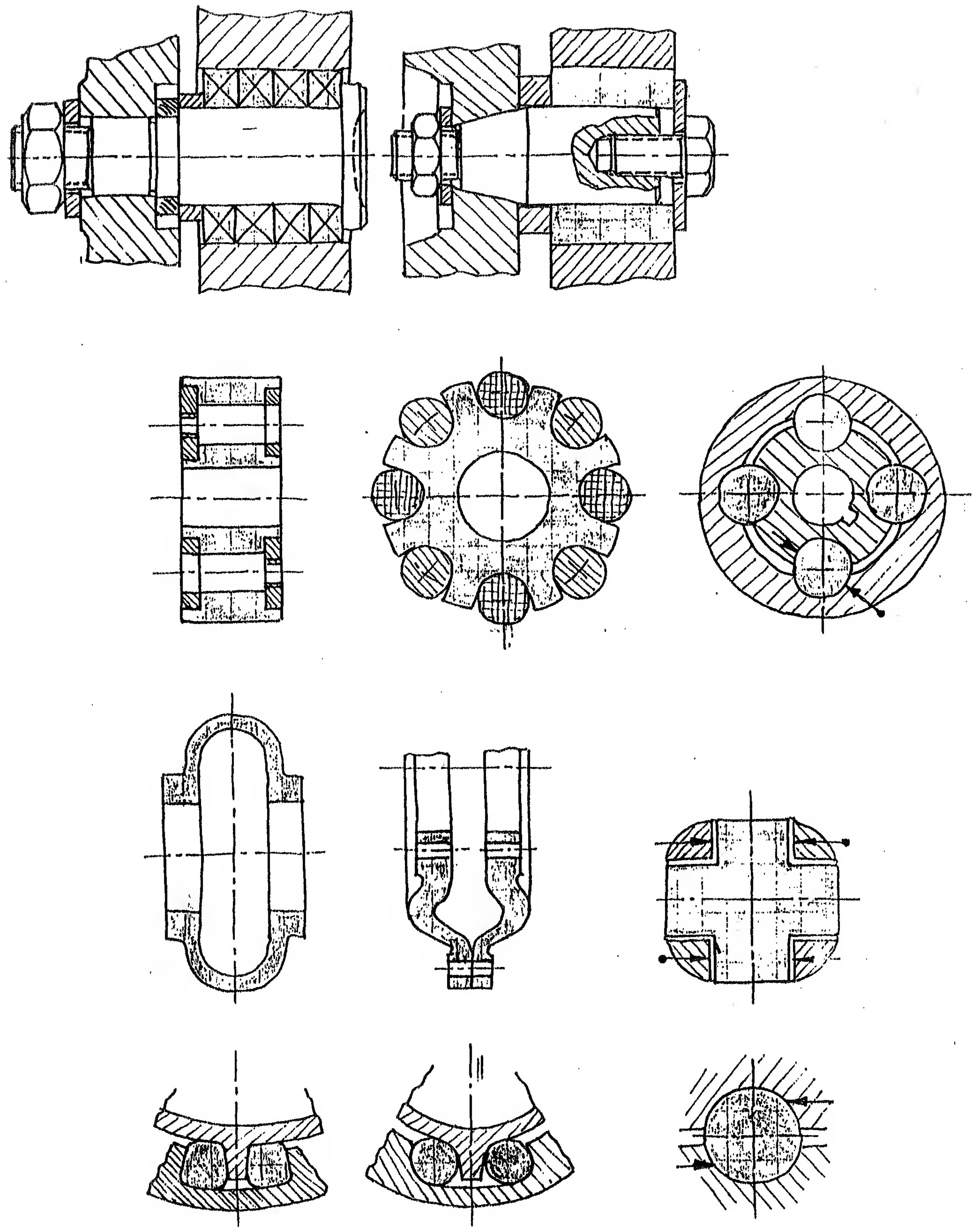


Clamp Coupling



Friction Grip Coupling

RIGID Couplings



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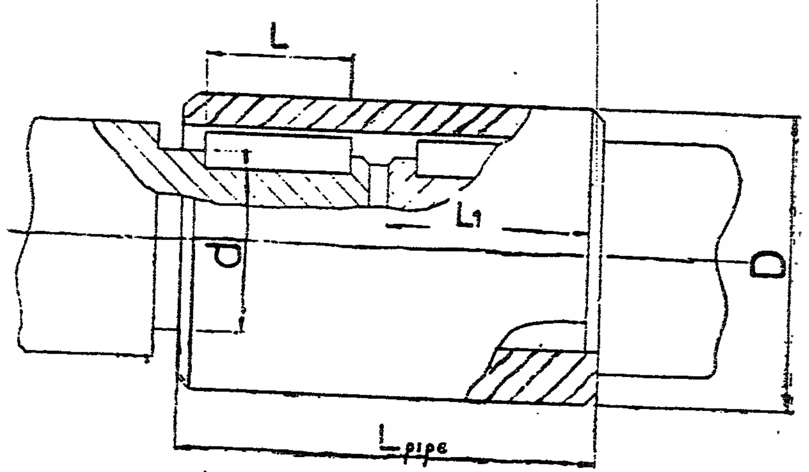
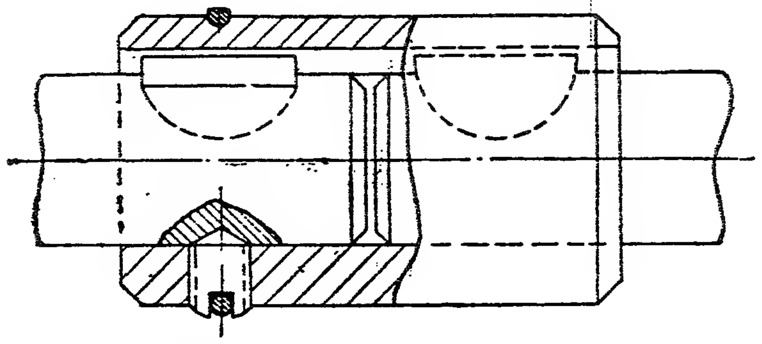
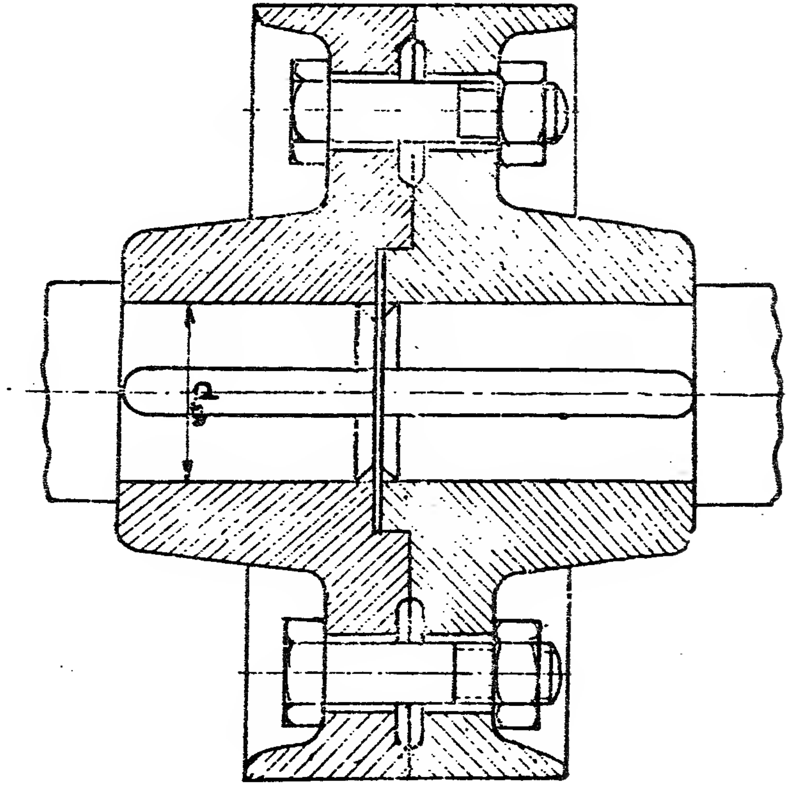


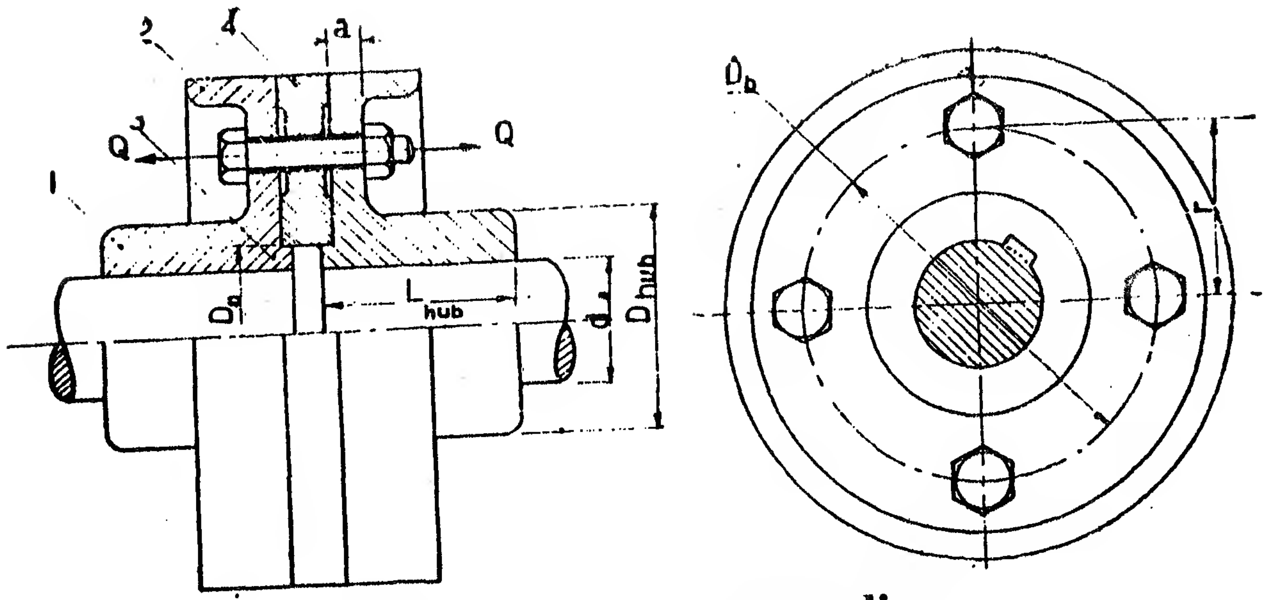
Rigid coupling with feather key



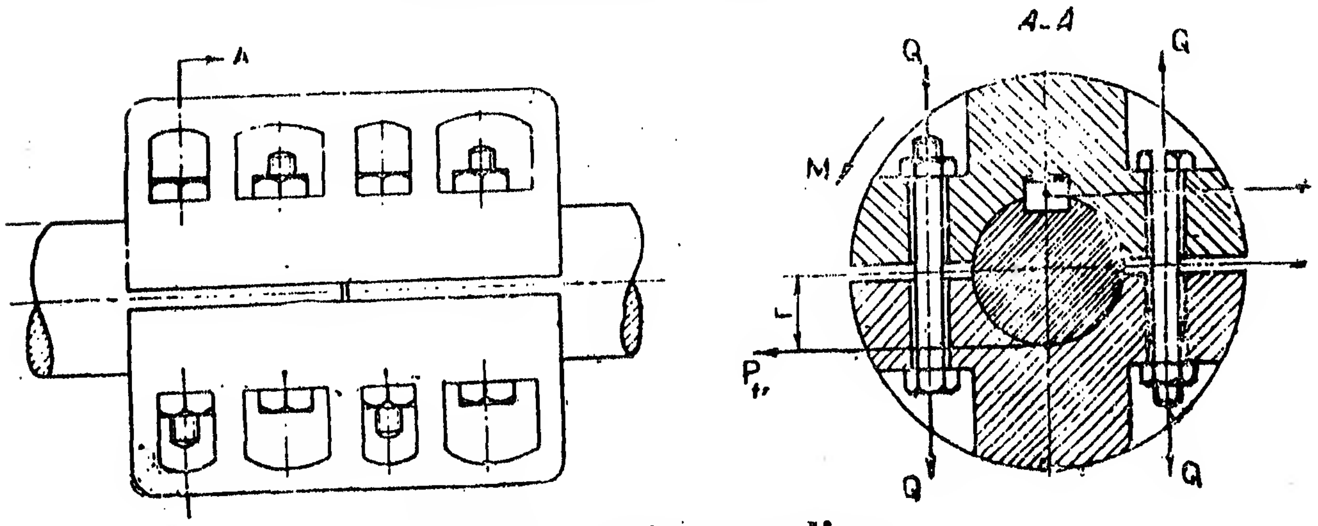
Rigid coupling woodruff



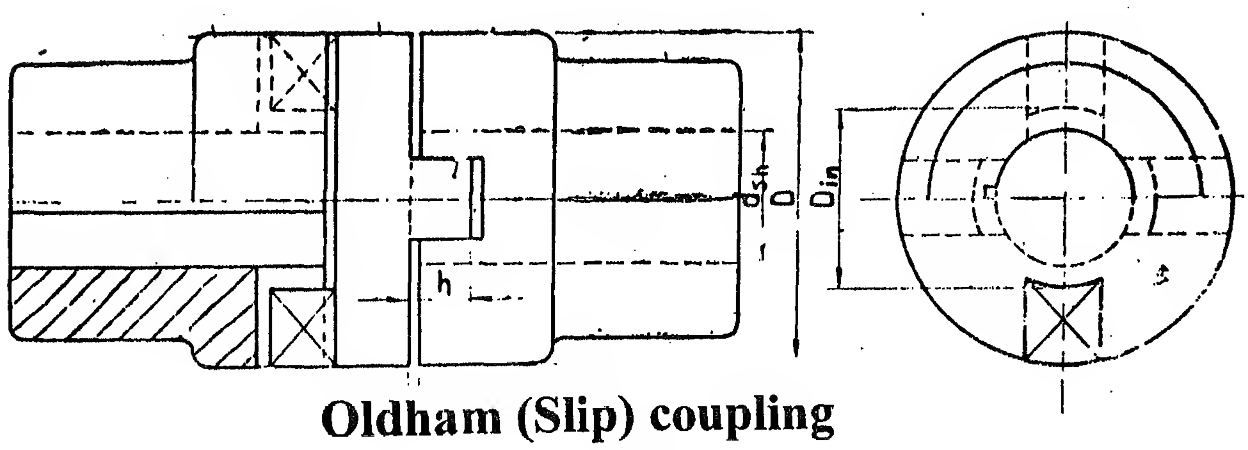
Rigid flange coupling



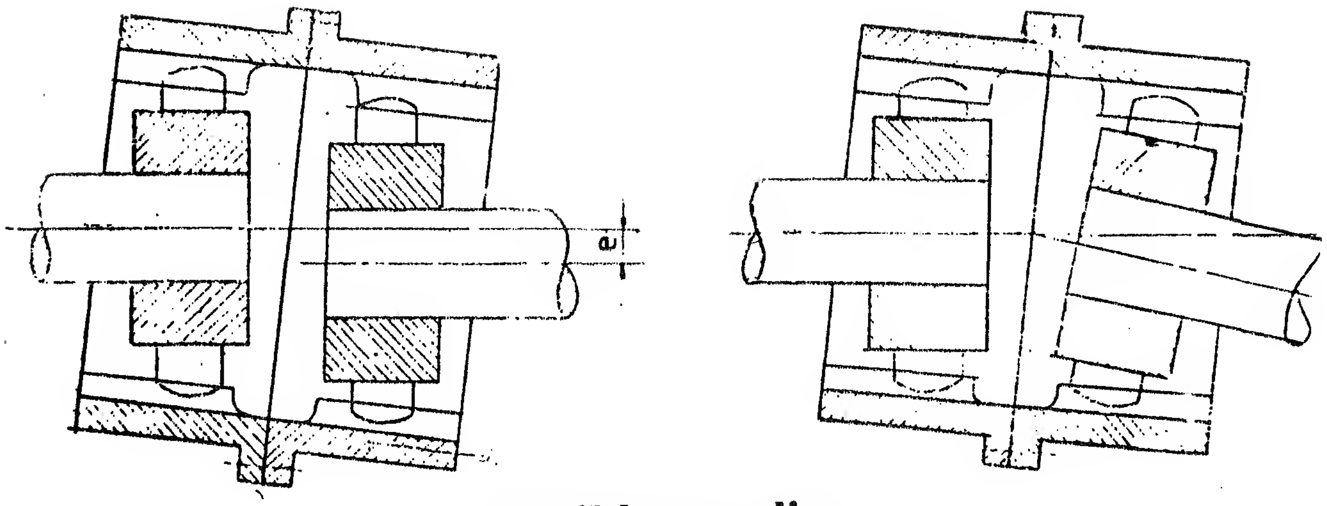
Friction disk rigid coupling



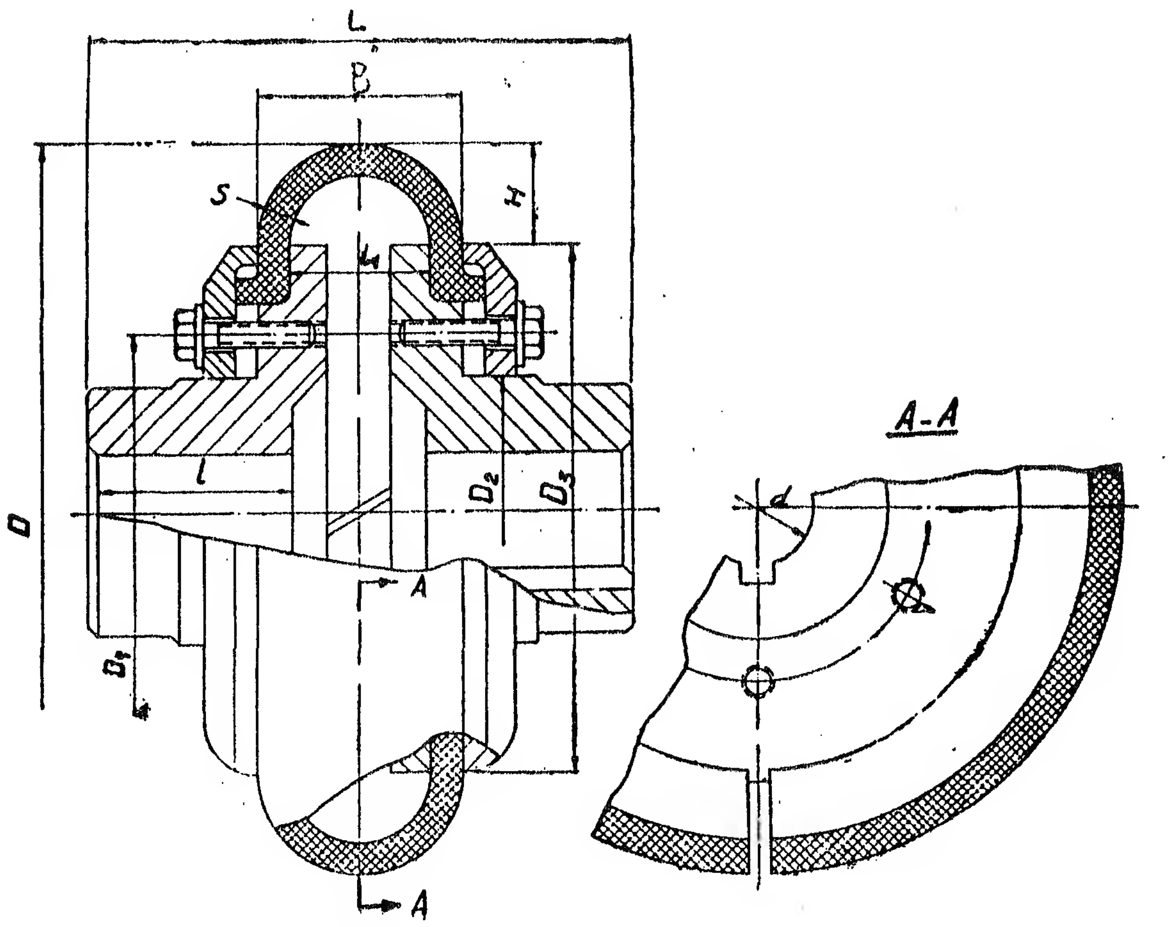
Friction grip coupling



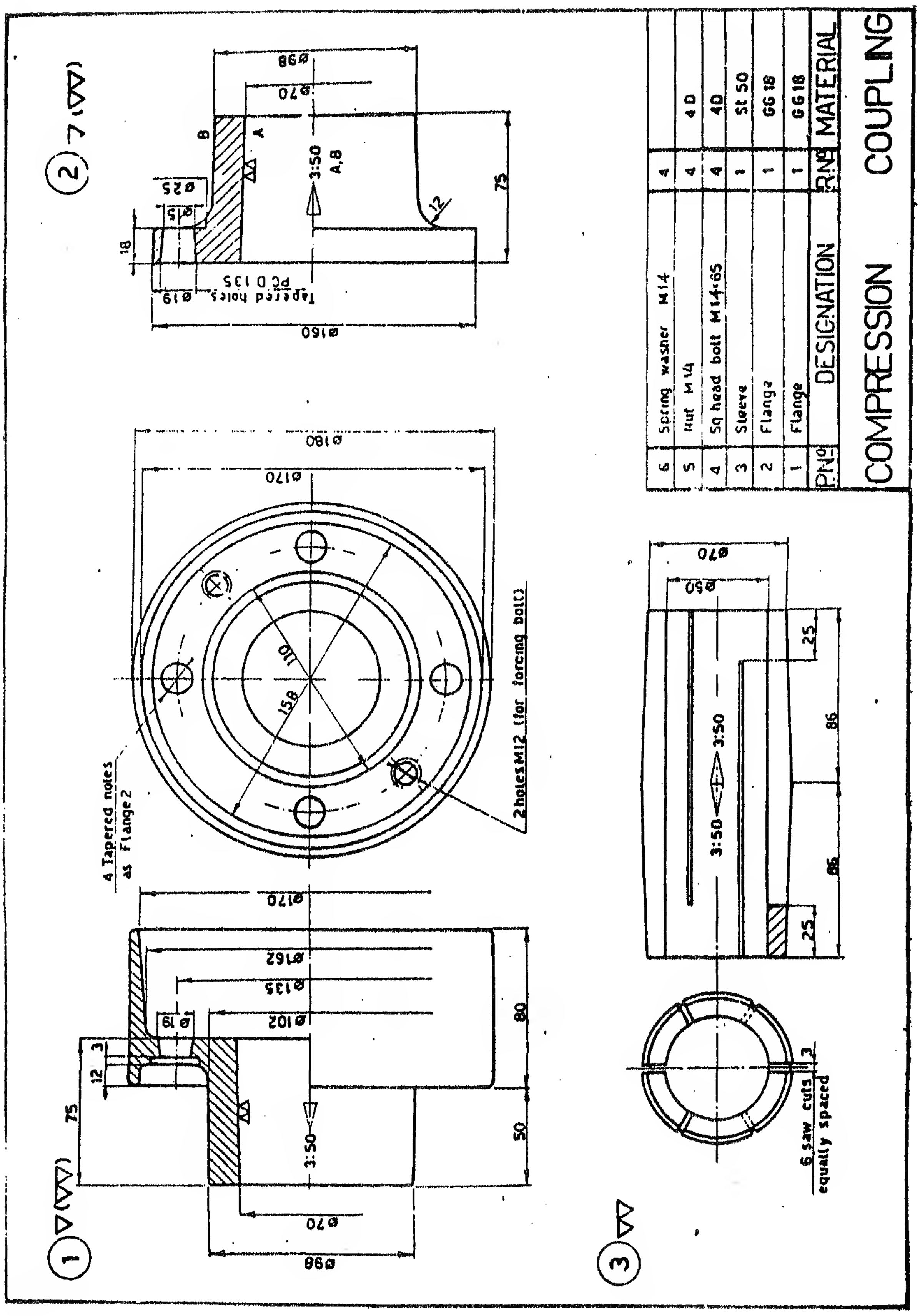
Oldham (Slip) coupling

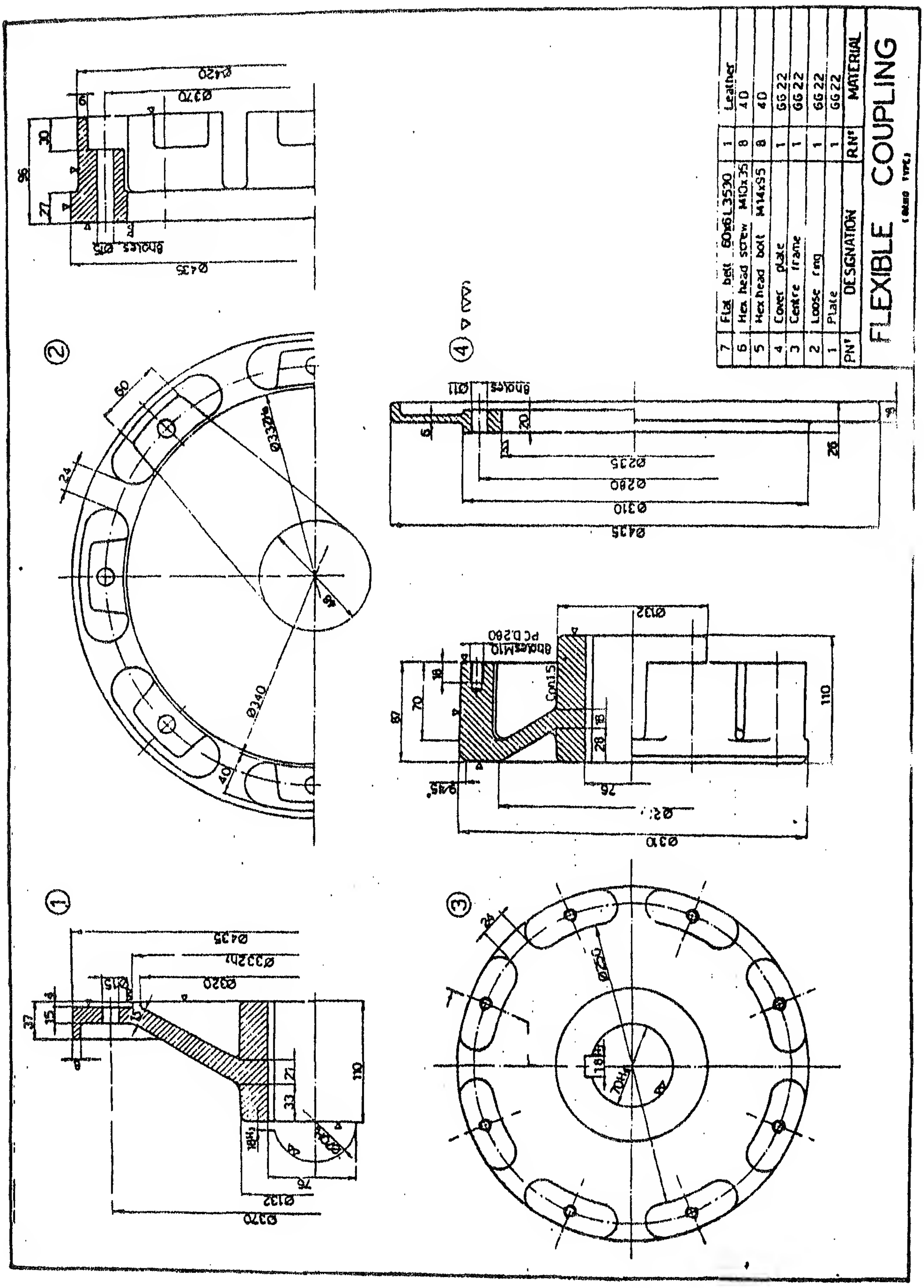


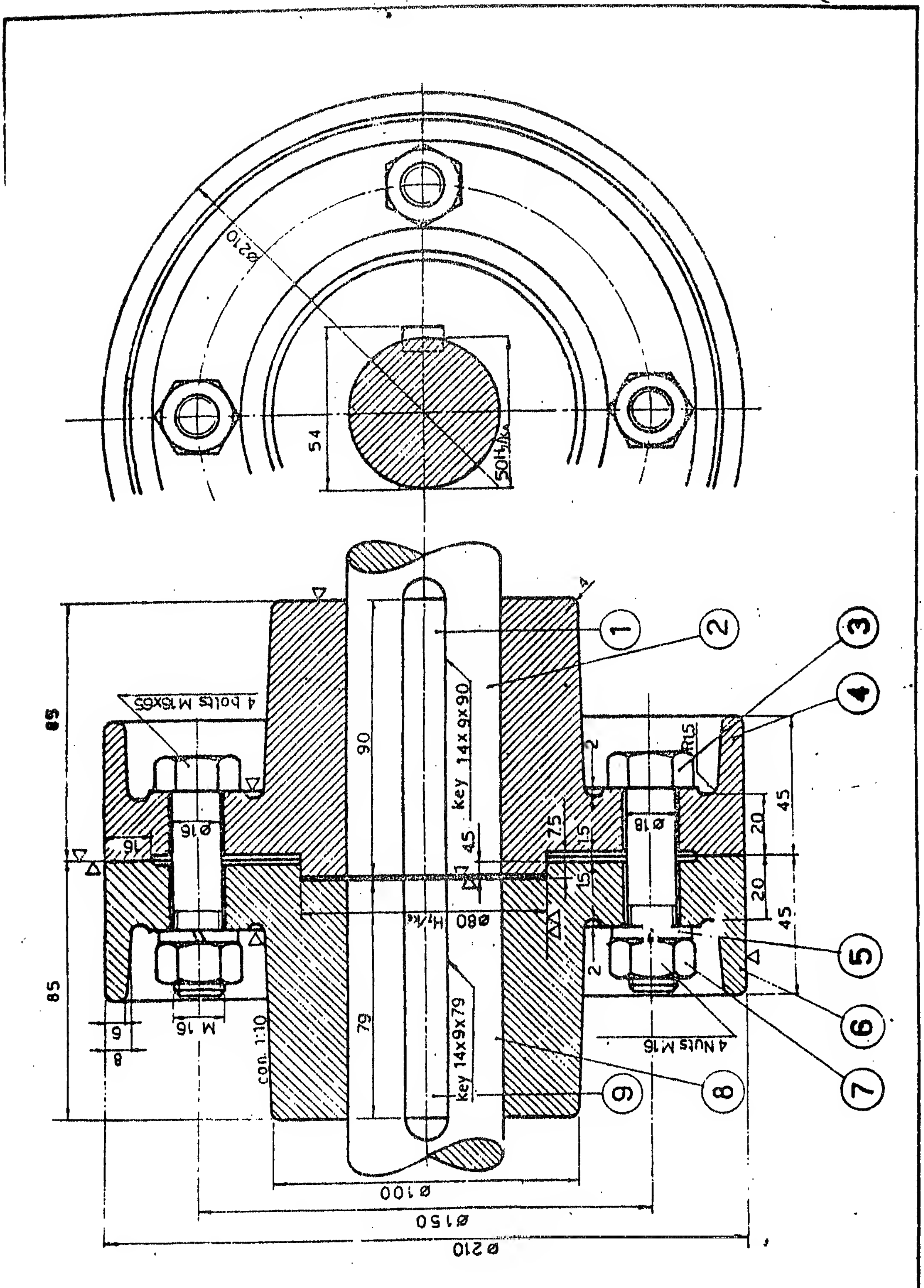
Flexible coupling



Flexible coupling with rubber tire


COMPRESSION COUPLING
P.Nº DESIGNATION RNº MATERIAL
1 Flange 1 GG 18
2 Flange 1 GG 18
3 Sleeve 1 St 50
4 Sq head bolt M14×65 4 4D
5 Nut M14 4 4D
6 Spring washer M14 4
4 Tapered holes as Flange 2
2 holes M12 (for forcing bolt)
Tapered holes PCD 135
6 saw cuts equally spaced


FLEXIBLE COUPLING
7 Flat belt 60x6 L3530 1 Leather
6 Hex head screw M10x35 8 4D
5 Hex head bolt M14x55 8 4D
4 Cover plate 1 GG22
3 Centre frame 1 GG22
2 Loose ring 1 GG22
1 Plate 1 GG22
PN° DESIGNATION R.N° MATERIAL



ø210
54
50H7/k6
4 bolts M15x65
90
key 14x9x90
45
ø16
16
ø80 H7/k6
79
key 14x9x79
con. 1:10
M 16
6
8
85
ø100
ø150
ø210
7.5
15
2
R15
ø18
20
45
4 Nuts M16
1
2
3
4
5
6
7
8
9

182.